**I. Force and Inertia:**

**1. Force:**

**a) Fists and fingers**- One person holds their fists together tightly. A second person will use their two index fingers to strike the fists sideways and separate the fists.

Reason- Forces up and down (vertical) are defenseless against forces pushing side ways (horizontal). The only help you get to keep your fists together is a small friction force.

**b) Dollar drop or reflex tester-** The catcher rests his wrist on the table to keep from following. The dropper holds the dollar vertically at the top. The catcher positions fingers on either side of George Washington's face, as close as he or she wants without touching the bill. When the bill is released, try to catch it with fingers. Impossible!

Why? The gravitational force on the dollar causes it to speed up instantly, outrunning the person's reflexes.  
  
**2. Inertia:**

**a) Card and quarter**- Place a quarter on a card, and the card on a middle finger being careful to place the quarter directly above the finger. With the other hand, try to flick the card out from under the quarter. An easier trick would be to place a card on top of a glass. Place any object on top of the card. Flick card and the object will fall into the glass.

Why it works- Objects have inertia and resist motion unless a force is applied. The force down caused by gravity is much greater than the small friction force pushing the object side ways.

**b) Books or other bodies in hurry**- Tie two light strings or threads to a book or other body. One person will hold up the book by one string while another person jerks lower string and note which one works. Then repeat and pull slowly on the lower string.

Why it works- A rapid jerk on the lower string is prevented from reaching the top string by the inertia of the book. A slow pull has time to transfer both weight of the book and pull top string breaking it first.

**c) Marbles and rice**- Place a marble in the bottom of a jar and fill the jar with rice. Rest a glass on one hand and apply sharp downward taps to the top rim of the glass with the other hand. The marble will rise to the top.

Why it works- Inertia of the marble is greater than the individual grains of rice. The tap delivers enough force to cause the rice to fall, but not the marble. So actually, it doesn't move, the rice falls out from underneath it.  
d) Paper trick- Hold onto two outside pieces of paper and try to jerk both off of the center one. Impossible! Repeat with weight paper clipped to the center piece.

Why it works- Inertia of all three pieces of paper is the same, so which ever piece is attached strongest remains attached. But with weight attached, inertia allows both ends to be jerked off without moving the center piece.

Materials  
two fists  
two fingers  
dollar  
dropper  
catcher  
card  
quarter  
finger (or glass)  
string  
body  
two experimenters  
marbles  
rice  
cup  
paper rectangles barely attached  
paperclips  
fifty cards  
small weight

**Ia. Conservation of Momentum**

1. Stand a 1 foot section of 4x4 up

Show kids two items, a racket ball and a ball of clay of the same mass as the racket ball.

Ask them which they believe will most easily knock over the block?

Racket ball turns it over the easiest.

Why ? The average force on the block equals the change in momentum of the object divided by the time interval required to bring the thrown object to a halt.

Assuming the time is approximately the same, the average force of stopping the ball is twice the stopping force of the clay, because the change in momentum of the ball is twice that of the clay.

2. Hold up a sheet and let kids throw eggs against the sheet to try to break them. It is virtually impossible.

Why? Because the force applied by the sheet to the egg is the change in the momentum of the egg divided by the time interval required to bring the egg to a halt. Since the egg stops much slower when thrown against a sheet than it does when thrown against a brick wall, the force is much smaller. Usually it is not enough to break the egg.

**II. Atmospheric Pressure and Bernoulli's Principle:**

**1. Straw in glass of water**- Level of fluid is same as level in glass.

Reason- Atmospheric pressure is inside the open straw as well as the glass.

**Force vs. Pressure**  
  
**2a.** Place finger over top of straw, shielding the top from the atmosphere. What happens if you pick up the straw?

Why? Atmospheric pressure pushing up from the bottom opening is more than gravity pulling down on the water, since there is very little pressure down from the top.  
  
**2b.** Fill glass with water and place a piece of paper on top. Ask what will happen when the glass is turned upside down. The water stays inside!

Why? Same reason water stayed in the straw with your finger over it (along with some surface tension).

**3a.** how do you lower pressure? Bernoulli's Principle  
Place one straw in water. Using a second straw, blow across the top of the straw in the water. What happens?

Why does water come out of the top? Increased velocity of air above the straw LOWERS the pressure there. Water is pushed up from the bottom by atmospheric pressure pushing down on the surrounding water in the glass.

**3b.** Will this work if you blow across the bottom of a straw full of water held up with a finger on top? Try it.  
  
**4. The Paper House:**  
Build the paper houses ahead of time. Blow through them and see how they hug the table. Then cover one end with the ruler and blow across the top (maybe using the straw) and see what happens. Ask them to explain this. Answer- When you blow through the house, low pressure is created inside, and atmospheric pressure pushes down from the top. When you blow across the top, low pressure is created just above the house and atmospheric pressure inside the house pushes it up!

**5. Grand Finale!!** Demo the beach ball and blower, then let them try with the cheese balls and straws.

Materials  
three glasses  
three tubs  
lots of straws  
many paper houses  
three rulers  
puff balls  
beach ball  
leaf blower

**III. Rotational Inertia:**

**1. Rotational Inertia: Resistance to rotate: Describe and discuss each activity below beforehand**  
a) Release meter stick and ruler at the same time and let them fall.  
b) Balance a meter stick and clamp with clamp at the top and clamp at the bottom and see which is easiest to balance.  
Why? Because it has most rotational inertia.  
c) Get hoop, disk and ball and race them rolling down a ramp.  
d) Get bottles with little, half full, and full of water and race. (Note: all this is too much hassle, we switched to the two cans of soup)  
e) Do the same thing with sand.  
f) Get an Oreo, and push small nail through the center to make an axel and roll it down a track make of two rulers or pieces of wood. (We couldn't get this to work, cookies break, and it's hard to center the nail)  
  
**2. Changing Rotational Inertia: Describe and discuss each activity below beforehand**  
a) Stand or sit on a rotation device. Hold small weights in out stretched hands. Get someone to spin you, then slowly bring arms to chest and back out again.  
b) Hold spinning bicycle wheel while standing or sitting on rotational device. Invert the bike wheel and see what happens.  
c) Tie string to one axle of the bike wheel, set it spinning and drop the other axle.

**Materials**  
2 meter sticks  
2 rod clamps  
2 rulers  
3 each of hoop, disk and ball  
1 small bike wheel  
1 large bike wheel  
1 rotational motion stool or platform  
20 cylindrical, wide mouth bottles with lids  
water & sand  
1 can of chili and 1 can of chicken broth  
Oreos  
box of 3 inch finishing nails

**IV. Heat Conduction and Temperature:**

**1. Heat Conduction:**   
a) Wrap paper around wooden stick and try to burn it. Repeat with a metal rod. Why it works- Metal conducts heat away so paper doesn't get hot enough to burn. Wood doesn't conduct heat very well.

b) Get copper, bronze, aluminum, and steel rods the same length. Get people to hold all in a flame and see who gets burnt the fastest. Why? Different materials have different amounts of conductivity.

c) Hold metal and Styrofoam of the same temperature. Why does the metal feel cold and not the Styrofoam?

**2. Heat Convection**:

a) Use a cigarette lighter to boil water in a paper cup. Why it works- Paper conducts heat to the water and the warm water rises, carrying away heat to prevent burning.

b) Try again with a Styrofoam cup. Why doesn't it work? Styrofoam cups do not conduct heat as well as paper, so all the heat remains to burn the cups.

**Materials:**

a dozen sheets of scrap paper  
1" metal rod  
1" wooden dowel  
copper, aluminum, brass, and steel rods, nails, screws, wire, something.  
Piece of metal  
piece of Styrofoam  
cigarette lighter  
package of paper cups  
package of Styrofoam cups

**V. Buoyancy & Pressure:**

**1. a.) Can you float a full cup in a quarter cup of water?**

Why it works: Buoyant pressure depends on depth, not quantity. When water rises to level of water is inside cup, it will float. The deeper the water the greater the pressure.  
  
**b. Poke three holes in a carton and put tape over the holes.** Fill the carton with water and then remove the tape. Which hole will allow the water to travel the greatest distance?

The point: Pressure is greater with depth.

**2. Float small cup in beaker of water.** Add stones or marbles until cup is barely floating. Mark water level in beaker. What will happen to water level when we take the marbles out of the cup and let them sink to the bottom of beakers, then put cup back in water?

**Why it Works:** It takes more depth of water to push up enough to float the marbles displace when sinking to bottom

**3. Make a Cartesian diver in a bottle.**

Why it Works: Pressure is distributed evenly throughout the bottle when you squeeze it's sides. The pressure compresses the air bubble inside the diver, making the diver more dense than water, so it sinks.

**Materials:**

Package of clear plastic cups  
20 2 liter clear soft drink bottles  
2 cups of marbles  
2 dozen 20 ounce clear plastic soft drink bottles with lids  
1 box of #6 or #8 brass nuts.

**VI. Electricity:**

**Static Electricity**:

Rub plastic comb in your hair or on your clothes and hold it near: Bits of paper, make a ping pong ball dance; bend a thin stream of water; light a fluorescent light by rubbing with balloon.

Why it Works: Changed particles are rubbed onto the comb, which polarizes objects then attracts them.  
  
**Electric Current:**

Wire a complete circuit with one battery and one bulb. What's happening?  
Answer: Electrons moving their circuit!

Build a sing 6-pole switch.

Connect a round and long bulb in series in circuit. Discuss why one lights and one does not.

Build the three-way switch.

**Materials:**

1 dozen plastic combs  
2 dozen ping pong balls  
8 bulb holders  
8 round bulbs  
8 long bulbs  
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